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Effect of Balance Training on Gait in Obese Older Adults

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Abstract: ***Objective**: The aim of the study is to find out effects of balance training on gait in obese older adults. **Background**: Obesity is rising at an alarming rate and as in obese older adults the risk of fall due to poor posture balance is seen increased. Obesity can result in many health problems. One of them is balance control inefficiency. Obesity modifies body geometry by adding mass to different regions and it influences the biomechanics of the body. As a result of which centre of mass (CoM), line of gravity (LoG) shifts. Resulting in falls and injuries. **Methodology**: The study is intervention based with the study set up at outpatient physiotherapy department of Nanded physiotherapy college and research centre. 31 subjects were randomly selected with inclusion criteria both obese older male and female > 60 years with BMI> 30kg/m^2 and exclusion criteria with reports of lower limb injuries, neuromuscular disorders and any condition resulting in non-weight bearing of leg. **Procedure**: 31 obese older individuals were selected. Clinical balance tests such as single leg stance, timed up and go, 10m walk test were performed on each subject before the intervention period started. The intervention period was of 4 week were each individual underwent balance training which included standing on different surface for vestibular and proprioceptive enhancement change in centre of gravity positions doing wall squats, timed up and go sit to stand and lunges, for gait tandem walking, sideways walk, forward as well as backward walking was incorporated. **Result**: There is significant effect of balance training on gait in obese older adults.*

Keywords: Balance training, obesity, BMI, gait, older adults.

1. Introduction

Obesity is defined as abnormal or excessive fat accumulation that may impair health. Obesity modifies body geometry by adding mass to different regions and it influences biomechanics of the body. Body mass index is a simple index of weight for height that is commonly used to classify overweight and obesity in adults. Obesity has been increasingly cited as a major health issue. BMI is a good indicator.

Classification	BMI (kg/m^2)	Comorbidities
Underweight	<18.5	Low
Normal range	18.5-24.9	Average
Overweight	>25	Increase
Pre-obese	25.0-29.9	Increase
Obesity class 1	30.0-34.9	Moderate
Obesity class 2	35.0-39.9	Severe
Obesity class 3	>40	Very severe

Obesity is rising at an alarming rate for older adults. The prevalence of obesity (BMI> 30 KG/M^2) is higher in older adults aged 60 years and over approximately 37% more than that in younger adults. [1, 2] It is estimated that over 1.9 billion people suffer from being overweight worldwide. [1]

600 million of whom are classified as obese depending on WHO report. Obesity is found to be associated with risk factors for various health conditions [e.g. cardiovascular disease, stroke and diabetes. [1]

Obese individuals are found to have higher chances of sustaining injury compared to lean counterparts. Obesity can interfere with daily activities which may result in different injuries and fall. One of the daily activities altered among obese individuals is balance control. Balance control is a key factor in prevention of related injury.

Overall somatosensory stimuli are needed for balance control. These stimuli include somatosensory, visual and vestibular. Integrity of such a system is vital to sustain proper posture. Sensory data are adjusted dynamically and changed according to environmental changes. The relation between body weight and postural control was first suggested by some researchers in 1968. [1]

Waist circumference, endomorph and body weight are considered as key factors affecting postural test among individuals with excessive weight. Size and shape of body significantly affect the static postural condition due to centre of body mass changes. [[14]

Postural control which can be either static or dynamic refers to a person's ability to maintain the stability of the body. Postural stability depends, in part, on the individual's BoS. Unless every part of the body is supported on a fixed surface, the influence of gravity and inertia create a constant external force to produce movement within the limits of stability. [15]these small amounts of movement represent subtle and often visually imperceptible motion known as postural sway.

Static posture, therefore, is not one single point, but is instead an area within which individuals can maintain their CoM and LoG within their BoS maintainence of static posture is dependent upon orientation and integrity of body segments, resting muscle tone and small magnitude of muscle activation. Balance is the process by which upright posture is maintained. Postural control is responsible for achieving, maintaining or restoring appropriate balance. When forces are in equilibrium. When forces are in equilibrium, the body remains at rest, or static, and is considered stable. Balance is more than simply a mechanical issue, and it requires multiple systems to ensure that the body maintains equilibrium. [5]

Maintaining the body's center of mass (COM) within the boundaries of its BoS is a requirement for maintaining stability, or balance, and is the ultimate goal of postural control. In standing anatomical position, the human's BoS is bounded by the area from the back of the heels circling the tips of the toes, and the CoM is located at approximately the level of the second sacral segment in the midsagittal plane. In a seated posture, the base of support (BoS) now includes the boundaries of the feet as well as the outline footprint of the item that the individual is seated upon. When seated, balance is dependent on the CoM of the head, arms, and trunk because the pelvis and lower extremities are supported. Theretore, when seated, the CoM shifts superiorly to a region just below the axilla. [5]

Redistribution of the limbs will alter the position of the individual's CoM and LoG. Characteristics such as age, height, and weight may alter the CoM and, therefore, vary the requirements for stability. Human balance also requires a complex interplay between the mechanical properties of the musculoskeletal system and the integrity of the central nervous system. [16]

Obesity significantly changes the way the body moves by causing changes in anthropometry. Increased body weight and mass modify how the limbs and whole body create and react to forces. Excess adiposity also interferes with the interaction of joints and muscles that are crucial to functional capacity and postural balance. [17]

Gait abnormalities also reflect balance impairments. Gait may be compromised through reduced velocity, cadence, step width, and step length, as well as through increased stance duration. Older adults who are less able to control or adapt these gait attributes to the environment may have difficulty avoiding obstacles which contribute to falls. Reduced gait speed among older adults is significantly related to balance measures. [18]

Older adults who experience falls are more likely to demonstrate reduced leg strength that may inhibit the ability to maintain postural balance. Muscle strength may be especially important in the ability of older adults to prevent a fall by recovering balance after perturbation. During balance recovery, it is essential to harness lower body muscle strength, both by producing a high rate of torque generation for motion correction and by coordinating movements at the knee and ankle joints. Muscle fatigue also contributes to the reduction of muscle strength, and has the potential to reduce both force production and balance control by increasing postural sway and altering attributes of gait. [12]

Although epidemiological studies link increased fall risk to obesity in older adults, the mechanism through which obesity increases falls and associated fall risk is lacking. Previous available studies have mostly focused on the effect of weight loss on postural stability without balance training. Also, most of these studies have been conducted on relation between balance training and balance improvement. However to the best of our knowledge, the effect of balance training exercise has not been examined among obese older adults among obese individuals. [2]

Thus, the present study aimed to assess the effect of balance training on clinical balance performance.

2. Need of study

Good balance is a key factor in daily activities. When obese individual moves forward in an oscillating manner, the specific abnormal adipose tissue distribution in the abdomen increases the need for ankle torque to establish balance.

Obesity can interfere with daily activities, which may result in different injuries and fall. Obese individuals are characterized by a reduced balance which has a significant effect on a variety of daily and occupational tasks. The presence of excessive adipose tissue and weight gain could increase the risk of falls; for this reason, obese individuals are at greater risk of falls than normal weight subjects in the presence of postural stress and disturbances. [13]

When forces are in equilibrium, the body remains at rest, or static, and is considered stable. Balance is more than simply a mechanical issue, and it requires multiple systems to ensure that the body maintains equilibrium. Maintaining the body's COM within the boundaries of its BoS. Requirement for maintaining stability, or balance, and is the ultimate goal of postural control. In standing anatomical position, the human's Bo is bounded by the area from the back of the heels circling the tips of the toes, and the CoM is located at approximately the level of the second sacral segment in the midsagittal plane. Human balance also requires a complex interplay between the mechanical properties of the musculoskeletal system and the integrity of the central nervous system. [5]

The most important factor affecting balance is the somatosensory system that is stimulated by specific balance exercises. Gait may be compromised through reduced velocity, cadence, step width, and step length, as well as through increased stance duration. Therefore we need to study if balance measures are associated with health related quality of life in obese older adults and can be a key factor in prevention of related injury.

3. Methodology

Study Type: Intervention Based
Study Duration: 6 Months
Sample Size: 31
Sapling Method: Random Allocation
Study Population: Obese Older Adult
Place of Study: Nanded Physiotherapy College And Research Centre OPD.

Criteria of study
Inclusion Criteria:
- Obese Older Adult > 60 Years, BMI > 30 Kg/M2
- Both male and female

- Voluntary participating subjects. .

Exclusion Criteria:

- Reports of lower limb injuries such as fractures, dislocations.
- Any condition resulting in non-weight bearing on leg. .
- Neuromuscular disorders.
- Musculoskeletal disorder such as rheumatoid arthritis.
- Any spinal cord deformities. .
- Significant neurological deficits.

Clinical Test

Single Leg Stance
SLS, in this static balance test, patients stand barefoot on one leg without support of the upper extremities or bracing og unweighted leg against the stance leg, with eyes open and closed. During the test with eye open they were looking at appoint on the front wall which was at eye level and in 2m distance. Then the test was repeated with the eye close.

Timed Up and Go
TUG, this functional balance test requires the patient to stand up from the chair, walk a short distance (3m) towards a wall, turn around without touching the wall, return and sit down again. The time needed for this purpose is measured

10 M Walk Test
10m walk test is employed to determine functional gait and vestibular function. The individual walks without assistance for 10m, start timing when the toes pass the start marking and stop timing as the toes pass the end marking. The time needed for this procedure is mentioned. It can be tested at either preferred walking speed or maximum walking.

4. Procedure

This clinical trial was conducted on 31 obese individuals. The participants were under intervention by random allocation. It should be noted that participation in the study was voluntary. An informed consent was taken from all the patients. All of them confirmed that their participation was voluntary.

Individuals height, weight were checked prior to treatment so as to fit in inclusion criteria of BMI >30 kg/m. Men and women of age > 60 years were selected and assessed for clinical balance performance. Prior treatment values were taken and patients were incorporated for interventions for a period of 4 weeks.

The program incorporated the interventions that included:

1) Static and dynamic stability of posture:
Which included standing on a leg in parallel bar with support, standing on a leg in parallel bar without support; sitting and standing up; tandem walking; sideways walking; forward walking; backward walking; single leg stance.

2) Different standing surfaces
Which included standing barefoot on a hard surface or floor, standing on a foam mattress, standing on a plinth with toes apart and in vicinity.

3) Variations in the height of the center of gravity
Timed up go changes the CoG from sitting to standing to walking and again sitting. This helps in maintaining the dynamic balance. Squats were used to intervene in a patient with assistance of members to hold hands; later the individual was found maintaining the balance, which was later found helpful in maintaining and improving the strength

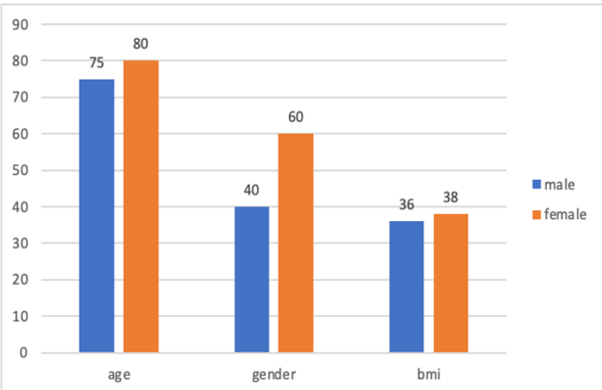
Perturbation-based balance training (PBT) is a form of reactive balance training that was executed to improve reactive balance control after unexpected external perturbations. These perturbations elicited rapid postural responses, training reactive postural control. PBT reduced fall risk, improved postural control and gait in the clinical population, as such healthy elderly people. PBT potentially stimulates the sensory motor control system, causing quicker muscle response to unpredictable perturbations and hence better balance reactions. [16]

- In a safe and controlled environment, participants were repeatedly exposed to destabilizing perturbations during the sessions.
- Balance boards were incorporated in perturbation based balance training.
- Besides improving balance and reducing falls incidence, PBT have significantly reduced the fear of falling. Fear of falling can have a major impact on older adults.

At the end of the period of 4 weeks the BMI was again assessed. The findings were comparatively very less than the one taken earlier prior to the beginning of interventions. The clinical balance performance showed marked change in values.

5. Result

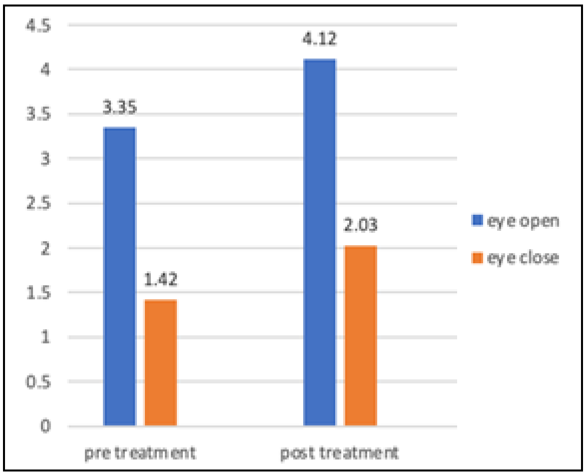
At the end of the 4 weeks the findings noted were significant. SLS duration with eye open as well as closed both were increased. Individuals over the period of 4 weeks were under the balance intervention which was on assessment found decreased in the time period required for both TUG AND 10m walk test.



Graph 1: Subjective data required for study

Table 1: Comparison between Pre-Intervention and Post-Intervention for Single Leg Stance (SLS)

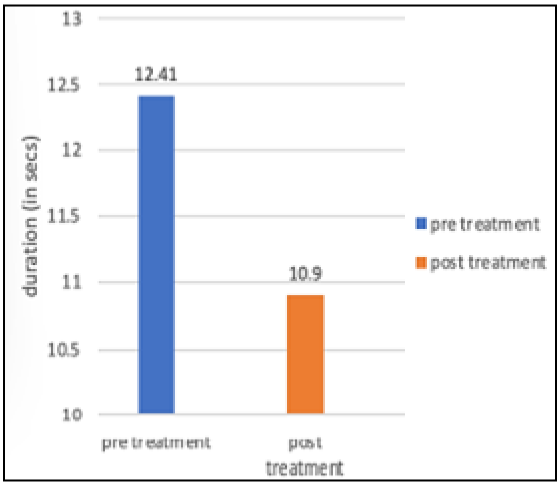
Variable	Mean± SD	t Value	p-Value
Pre-treatment			
Eye Open	3.35 ± 2.12	4. 192	<0.0001
Eye Close	4.12 ± 2.13		
Post-treatment			
Eye Open	1.42 ± 2.14	3.197	<0.0001
Eye Close	2.03 ± 3.53		



Graph 2: Pre-treatment and post-treatment duration comparison between single leg stance during eye open and close

Table 2: Comparison between pre-intervention and post intervention for TUG

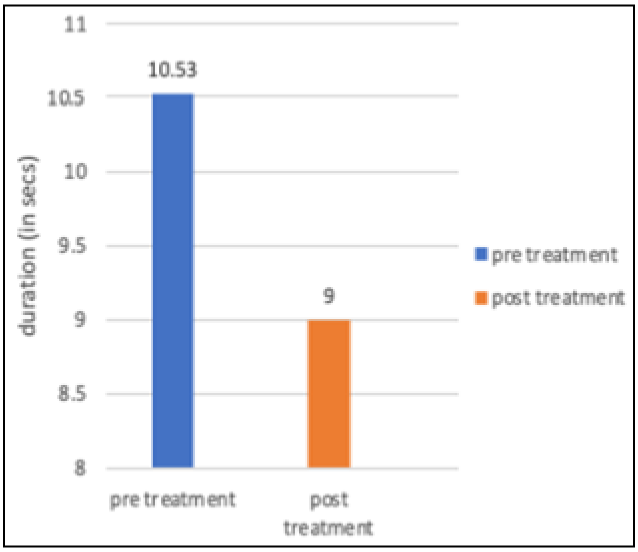
Variable	Mean± SD	t Value	p-Value
Pre-treatment	12.41± 5.65	1.492	<0.043
Post-treatment	10. 90± 6.36	2.041	<0.043



Graph 3: Pre Treatment and Post Treatment comparison of duration required for timed up and go test

Table 3: Comparison between pre-intervention and post intervention for 10 m walk test

Variable	Mean± SD	t Value	p-Value
Pre-treatment	10.5± 4.94	3.315	<0.189
Post-treatment	9.0± 4.89	2.466	<0.189



Graph 4: Pre-treatment and post-treatment comparison of duration required for 10 m walk test.

Statistical Analysis

Data analysis was done using the Statistical Package for Social Sciences (SPSS version 21). Basic descriptions were presented in the form of mean and Standard deviation. The data were assessed for normality using the Shapiro-Wilk test. Paired 't' test was used to analyze the pre and post differences for single leg stance (SLS), timed up and go (TUG) and 10 m walk test. Pre and post scores were compared using the Wilcoxon rank signed test. The level of significance was set at $p < 0.05$ for all tests.

In Paired sample t-test pre-intervention mean and standard deviation of single leg stance (SLS) with eye open was 3.35±2.12 & 4.12±2.13 in eye closed whereas Post intervention mean and standard deviation of SLS was 1.42±2.14 in eye open and 2.03±3.53 in eye closed.

Pre-intervention mean and standard deviation of timed up and go (TUG) was 12.41±5.65 whereas post intervention mean and standard deviation of TUG was 10.90±6.36.

Pre-intervention mean and standard deviation of 10 m walk test was 10.5±4.94 whereas post intervention mean and standard deviation of 10 m walk test was 9.0±4.89.

Pre and post NPRS scores were compared using Wilcoxon rank signed test. The level of significance was set at $p < 0.05$ for all tests.

6. Discussion

Obesity negatively affects the individual's daily activities and increases risk of injuries. The finding of this study showed that balance training significantly improved with the 4 week intervention. The clinical indicators of static, dynamic and functional balance performance were improved.

There are three important systems used for the control of posture. Balance is assessed by somatosensory, visual, and vestibular systems . Vestibular and visual systems. Thus, it canbe concluded that the most important factor affecting balance is the somatosensory system that is stimulated by specific balance exercises. So, this system may be responsible for better performance in postural control during clinical tests. Balance training that was used in this study included unusual activities such as walking on toes and heels, sidewalk, walking while one upper extremity and the opposite lower extremity are up. Participants performed these activities for 4 weeks, so these kinds of training could affect and improve the somato sensory system significantly. [1]

Besides, Clemson et al. conducted Lifestyle integrated Functional Exercise (LiFE) program, which included balance and strength activities, among individuals with the mean age of 70 years for 12 months. The findings of that study showed an improvement in static balance among these individuals. [1, 6]

Moreover, Hauer et al. investigated 57 women with the mean age of 82 years. Balance training was performed three times a week for 3 months. The results showed an improvement in balance control and fall risk after 3 months. [7]

Similar to the present study, the above mentioned investigations revealed that balance training had a positive effect on improvement of balance control.

Obese individuals are typically sedentary as there is an inverse relationship between BMI and activity levels. An increase in BMI is not only negatively associated with physical activity levels, but it is also associated with an increase in functional impairment, which could possibly lead to impaired balance and an increased risk of falls. Consequently, obese individuals may fear falling, which may lead to further reduction in physical activity, greater functional impairment. Activity programs including resistance training, stretching and an increase in balance confidence have shown to decrease the fear of falling and thus have a positive impact on the elderly.

In older men and women, obesity was associated with a higher prevalence of falls and stumbling during ambulation, as well as lower values in multiple domains of health-related quality of life. Furthermore, a history of falls and ambulatory stumbling were related to lower measures of quality of life in obese men and women. Future studies appear warranted to assess whether weight loss interventions improve quality of life and reduce the risk of falling in older obese adults. [3]

A significant increase in sway parameters (circular area, ellipse area, and path length) were also observed in obese elders. Traditionally, greater COP displacements have been linked with less stability and, consequently, increased fall risk. This implies the motor system was unable to adjust to the demands inherent in obesity during stance, resulting in diminished adaptability and stability. In this context, the increase in sway area and path length may be a result of impaired feedback control or impaired proprioception/ vision/ vestibular system leading to a reduced adaptive capacity of the postural system (Manor et al.2010). [2, 8]

Moreover, the firing of postural muscles may follow an adaptive strategy to reduce joint loads in obese older individuals that diminish postural stability. From a biomechanics perspective, it may also be due to the inability of older people to control and accelerate the whole-body center-of-mass (COM) over the base of support, perhaps due to lack of strength and degradation of type I fibers in skeletal muscles. [9]

While muscle strength was not objectively measured in this study, it has been documented that many older people have relatively weaker tibialis anterior and vasts laterals muscle strength compared to that of healthy adults making them more susceptible to falls.

Journal of neuroenginnering and rehab study to investigate the effects of long-term (eight-week) balance training with and without vibrotactile SA on clinical outcome measures for community-dwelling older adults. Analysis of the twelve participants' scores showed that both the EG and CG had significant improvements. This is the first study to investigate the effects of long-term (eight-week) balance training with and without vibrotactile SA on clinical outcome measures for community-dwelling older adults. Analysis of the twelve participants' scores showed that both the EG and CG had significant improvements in SOT composite scores, vestibular reliance, Mini-BESTest28, Mini-BESTest32 and TUG-COG duration; however, the EG improved significantly more than the CG in SOT composite scores, Mini-BESTest28, and Mini-BESTest32. In addition, significant improvements in 5xSST duration were found within the EG, whereas no significant improvements were found within the CG. However, no significant improvements were found in the ABC score, somatosensory reliance, visual reliance, FSST duration, FRT, gait speed, and TUG duration. After training, both groups showed improvements in the SOT composite score; significantly greater improvements were found for participants trained with SA than without SA (8 points vs. 5 points at mid-training, 12 points vs. 3 points at post-training on average). [10]

NLM investigated the effects of a combined balance and strength training program on balance and muscle strength in older women and compared this to an active control group receiving only conventional physical therapy. Our results show that combined balance and strength training using a visual feedback-based force platform improved displacement, and COG velocity mobility in the WBS, STS and improved the participant's ability to shift their COG laterally, forward and backward to maintain static and dynamic balance. Furthermore, the 8-weeks strength and balance training program resulted in significant group × time interactions for the percentage distribution of body weight between legs at different conditions of knee flexion (0°, 30°, 60°, and 90°) and also decreased the sway oscillation under four conditions (firm EO, foam EO, firm EC, and foam EC) in the IG. These results suggest that a combined balance and strength training program including visual biofeedback improves static balance in older women, and will likely reduce falls. [11]

Asymmetries were found in the study participants. Thus, it has previously been postulated that asymmetry between limbs may be predictive of future falls given that risk of falling increased with asymmetry. [11]

Obesity is often related to a lower level of physical activity, impaired cardiorespiratory fitness and knee strength compared tonon-obese individuals (Duvigneaud et al., 2008), possibly impairing the ability to correct for a shift in the body's center of mass and prevent falling. Increased postural sway could be an adaptive strategy to provide additional stability under conditions of weakness in muscles involved in postural control. A-related deterioration of sensory and neuromuscular control mechanisms could add to this problem. Degradation of balance shows that fall risk is increased in persons with higher BMI. [11]

A summary of knowledge about balance control in obese individuals and its limitations is important clinically, as it could give indications and suggestions to improve and personalize the development of specific clinical programs.

7. Conclusion

Obesity in older adults is undoubtedly recognized as an important issue with fall risk implication. However the relationship between obese older people and gait characteristics is little known. Among the several disabling conditions, an increase in BMI is associated with an increase in functional impairment, impaired balance and an increased risk of falls. [11]

Balance training along with conjunction of strength training may be the most effective intervention to improve balance capacity in the overweight and obese in order to reduce falls and improve quality of life. [1, 2]

Training programs inducing weight loss appear to be beneficial, even if this effect may tap at other processes. More studies are needed to assess effectiveness of balance training and weight loss programs in the long term in a wider population of obese subjects.

8. Limitation of the Study

1) Small sample size.
2) Heterogeneity in the health outcomes of older individuals [14].
3) Individuals appear frail and require assistance in daily routines
4) Biological age is a major predictor of fall risk rather than chronological age.
5) We have also reported earlier that sensitive motor control measures like dynamic stability which can differentiate fall-prone older individuals from age matched healthy older adults.

9. Suggestions

1) Further studies with more patients are recommended.
2) The quality of life after attending balance exercise sessions should be assessed.
3) Differences between obese older male and female’s clinical balance performance should be studied.
4) The variation on gait and postural stability among the two respective genders is suggested.

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